Flavor of Evaporated Milk. II. Changes in Flavor on Storage of Evaporated Milk Made by Three Processes [1]

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Abstract

The flavor stability of evaporated milk made by the conventional, high-temperature short-time, and aseptic processes was determined on storage at 10 and 27 C. There was a significant effect of processing on the initial flavor score and on the effect of storage on the product at the two storage temperatures. The aseptic process yielded the best-flavored product initially and it remained the best for about two months at 10 and 27 C storage. After two months the aseptic process showed very little advantage over the high-temperature short-time process. Evaporated milk made by the conventional process had the poorest flavor initially and throughout storage.

In a previous publication (1), it was reported that an aged evaporated milk made by the conventional process contained numerous flavor producing compounds. This study was undertaken to determine the flavor stability of evaporated milk processed by 1) the conventional method, 2) the high-temperature short-time (HTST) method, and 3) the aseptic method on storage at 10 and 27 C.

Experimental Procedure

All of the evaporated milk was manufactured from the same milk, obtained from the University of Illinois dairy herd. Twelve thousand pounds of milk were cooled to 5 C and transported in an insulated tank truck to the Pet Milk Company condensary in Greenville, Illinois. On arrival, the milk was stored overnight, separated in part, standardized, and concentrated in three batches. The data in Table 1 show all the pertinent conditions of preheating, concentration, and sterilization. The milk earmarked for the manufacture of evaporated milk by the HTST and aseptic processes was preheated in the Roswell Heater connected with a 2.5-min holding tube. The difference between the ingoing and outgoing temperature was due

TABLE 1
Processing conditions for evaporated milks

	HTST	Aseptic	Conventional
Amount of milk *(kg)*	1,360	1,360	1,813
Flow rate *(kg/hr)*	953	953	1,360
Input rate *(kg/hr)*	953	953	1,360
Plate preheater temp *(C)*	81	81	77
Roswell Heater IN	111	110	
Temp *(C)* OUT	117	117	
Holding time *(min)*	2.5	2.5	
First hot well temp *(C)*			93
Second hot well temp *(C)*			98
Double-effect pans: (Arthur Harris & Co. Pans)			
1st-effect temp *(C)*	70	67	87
Vacuum *(cm Hg)*	50	51	29
2nd-effect temp *(C)*	44	42	47
Vacuum *(cm)*	66	66	62
Temp after steam injection *(C)*		113	
Holding time *(min)*		4	
Sp. Gravity	1.083	1.071	1.078
Tube chest			
vacuum *(cm Hg)*	7.6	3.2	
Pressure *(kg/cm²)*			0.35
Homogenization temp *(C)*	43	54	43
Homogenization pressure *(kg/cm²)*	246	127	246

The condensed milks were aged 40 hr, canned, and sterilized.

Data on sterilization and canning

Conventional:		
Atmospheric preheater	49-93 C in 17.5 min	
Sterilization at 116 C for 15 min		
HTST:		
Atmospheric preheater	49-93 C	
Pressure preheater	113 C for 4.3 min	
Sterilization	126 C for 2.3 min	
Aseptic:		
Preheater temp *(C)*		82
Sterilizer temp *(C)*		148
Sterilization time *(sec)*		3.8
Homogenizer temp *(C)*		68
Homogenizer press *(kg/cm²)*		
I Stage		35
II Stage		210
Input *(kg/hr)*		717
Cans/min		29

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to recirculation of some of the product through the heater. The condensed milk intended for the aseptic process of canning was further preheated by steam injection to 113 C and held for 4 min.

The evaporated milk made by the conventional and HTST processes was sterilized in a commercial Anderson-Barngrover continuous sterilizer. The product made by the aseptic process was sterilized in a Roswell heater and canned in a Martin Aseptic Canner. The composition of the evaporated milks ranged from 7.875-7.914% fat and 26.12-26.25% total solids.

Samples from each batch were stored at 10 and 27 C. Organoleptic evaluations were made at 4-wk intervals by a panel of seven judges—at least four judges taking part in each evaluation. The samples were reconstituted to fluid milk composition and judged at two sessions, half of them in the morning and the other half in the afternoon. The 12 samples (six different samples in duplicate) were randomly divided into two sets of six samples, one for each of the judging sessions.

An effort was made to standardize the scoring of the samples through conferences with all the judges and frequent practice sessions before initiation of the study. Evaporated milk is particularly difficult to judge, because of its strong flavor which causes rapid fatigue on the part of the judges. The conventional flavor-scoring system as used for fluid market milk was employed, with 40 representing a perfect score and 30 being the lowest limit of a marketable product.

The organoleptic data for the first 48 wk of

TABLE 2

Statistical data

Sources of variance	Degrees of freedom	Fitted constants (Regression coefficients)	Standard error	Significance (%)
Processing procedure:				
HTST vs. Aseptic (S_1)	1	0.974254	0.264945	0.1
Conventional vs. HTST + Aseptic (S_2)	1	0.502614	0.153359	0.1
Judges:				
1st vs. 7th	1	−0.130655	0.088685	N.S.
2nd vs. 7th	1	−0.516660	0.081729	0.1
3rd vs. 7th	1	−0.497058	0.088989	0.1
4th vs. 7th	1	0.833662	0.084441	0.1
5th vs. 7th	1	0.836645	0.105703	0.1
6th vs. 7th	1	−0.573812	0.106129	0.1
Time—10 C (t_{10})				
Linear	1	−0.254775	0.136313	5
Quadratic	1	−0.002719	0.023133	N.S.
Cubic	1	0.000664	0.001122	N.S.
Time—27 C (t_{27})				
Linear	1	−0.531608	0.136228	0.1
Quadratic	1	0.037375	0.023110	N.S.
Cubic	1	−0.001542	0.001121	N.S.
Interactions:				
$S_1 \times t_{10}$:				
Linear	1	−0.452849	0.164884	0.1–1.0
Quadratic	1	0.068175	0.028111	1–5
Cubic	1	−0.002903	0.001366	1–5
$S_1 \times t_{27}$:				
Linear	1	−0.411434	0.165530	1–5
Quadratic	1	0.057149	0.028225	5
Cubic	1	−0.002348	0.001370	N.S.
$S_2 \times t_{10}$:				
Linear	1	−0.009627	0.095379	N.S.
Quadratic	1	−0.004272	0.016280	N.S.
Cubic	1	0.000293	0.000791	N.S.
$S_2 \times t_{27}$:				
Linear	1	−0.119109	0.094976	N.S.
Quadratic	1	0.020079	0.016199	N.S.
Cubic	1	−0.000982	0.000787	N.S.
Standard error of estimate	715	1.041154		
Total	742			

Dependent variable intercept: 35.39945.

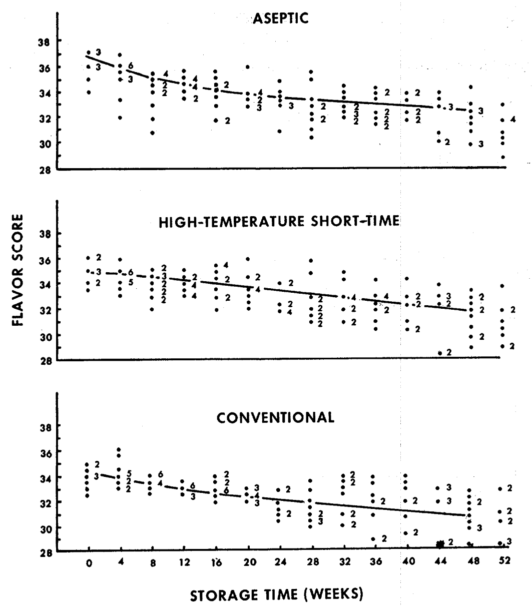

FIG. 1. Effect of storage at 27 C upon flavor of evaporated milks. (·—actual flavor scores. Curves calculated from regression equations. Figures opposite points indicate the number of judges reporting the particular score. Value marked by an asterisk in the bottom graph corresponds to a flavor score of 27.)

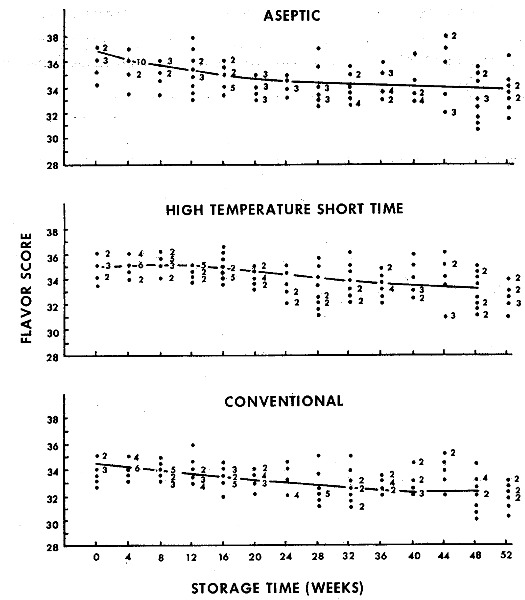

FIG. 2. Effect of storage at 10 C upon flavor of evaporated milks. (·—actual flavor scores. Curves calculated from regression equations. Figures opposite points indicate the number of judges reporting the particular score.)

storage were statistically analyzed on the IBM 7094 Computer. Since not all of the judges evaluated all samples presented, the subclass numbers were disproportionate and, therefore, the data were analyzed by the method of least squares. Fitted constants were obtained for the following: processing procedures; judges; time at each temperature of storage, separately, and the effect of processing procedure on the time effect at each storage temperature. Because storage temperature could have no effect at zero time, the requirement was placed on the analysis that for each processing procedure the regression lines for both temperatures have a common value at zero-time. Constants were evaluated for the effect of time and the cross products only up to the cubic coefficients, since it was felt that further terms in the regression equations would be of little value. The unit of time employed was the 4-wk interval from zero to twelve 0 (1) 12. The statistical data are given in Table 2.

The following fitted constants were employed in calculating the regression equations: dependent variable intercept and regression coefficients for processing procedure, time (linear, quadratic, and cubic), and interactions $S_1 \times t_{10}$ and $S_1 \times t_{27}$ (linear, quadratic, and cubic). Other regression coefficients were omitted, due to lack of either significance or interest.

Conventional Process:

10 C Storage
$$y = 34.394 - 0.25477t - 0.00271865t^2 + 0.00066407t^3$$

27 C Storage
$$y = 34.394 - 0.53171t + 0.037375t^2 - 0.0015422t^3$$

HTST Process:

10 C Storage
$$y = 34.928 + 0.19807t - 0.070894t^2 + 0.0035673t^3$$

27 C Storage
$$y = 34.928 - 0.12017t - 0.020112t^2 + 0.00080582t^3$$

Aseptic Process:

10 C Storage
$$y = 36.776 - 0.70762t + 0.065456t^2 - 0.0022392t^3$$

27 C Storage
$$y = 36.776 - 0.94304t + 0.094524t^2 - 0.0038902t^3$$

The curves in Figures 1 and 2 pass through the flavor scores calculated from the regression equations.

Discussion

Descriptive criticisms of flavor defects were also furnished by the judges, but such data are difficult to handle mathematically. The initial flavor of evaporated milk was generally described as cooked and caramel. Upon storage, other flavors appeared which different judges described as acidy, stale, storage, bitter, astringent, and puckery.

It is readily apparent from the statistical analysis that the judges constituted a major source of variance in the flavor score, and that, therefore, since not all of the judges participated in each flavor judgment, the mean flavor evaluation of the individual samples is biased. However, the statistical treatment of the data makes allowances for this source of variance in the regression equation and, therefore, the curves in Figures 1 and 2 constitute an unbiased representation of the changes during storage.

There is a significant effect of processing on the initial flavor score of the product, and the effect of storage time on the product at the two storage temperatures. Initially, the product obtained by the aseptic process was superior in flavor to the two other products. However, it deteriorated rapidly during the first weeks of storage, whereas the product obtained by the HTST process deteriorated very little in the first 20 wk of storage. The rate of deterioration of the product prepared by the conventional process apparently lies between the others, since the interaction comparisons $S_2 \times t_{10}$ and $S_2 \times t_{27}$ are not significant.

At the end of the storage period, the flavor scores of the products produced by the HTST and the aseptic methods were very close, whereas those for the product produced in the conventional manner were significantly lower.

As expected, the flavor of the products deteriorated more rapidly at 27 than at 10 C, regardless of the method of manufacture.

The aseptic process yielded the best-flavored product initially and remained the best for a period of about two months—both at 10 and 27 C storage. After two months the aseptic process had very little advantage over the HTST process. Evaporated milk made by the conventional process had the poorest flavor initially and throughout the storage study.

Acknowledgment

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Reference

(1) Muck, G. A., Tobias, J., and Whitney, R. McL. 1963. Flavor of Evaporated Milk. I. Identification of Some Compounds Obtained by the Petroleum Ether Solvent Partitioning Technique from Aged Evaporated Milk. J. Dairy Sci., 46: 774.